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Key to the genera and checklist of species of Australian temnocephalans (Temnocephalida)

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Abstract

Temnocephalans are small, active ectosymbiotic flatworms that in Australia are associated with freshwater crustacean hosts, particularly crayfish of the family Parastacidae. There are 91 named Australian temnocephalan species comprised of 13 genera, viz. *Didymorchis*, *Diceratocephala*, *Decadidymus*, *Actinodactylella*, *Temnomonticellia*, *Temnohaswellia*, *Achenella*, *Temnosewellia*, *Notodactylus*, *Craspedella*, *Gelasinella*, *Heptacraspedella* and *Zygopella*; most with distinctive dorsal facies. Methods to collect, handle and process temnocephalans are outlined. Techniques suitable to examine the sclerotic components of the cirrus and vagina for discrimination to the level of species are reiterated briefly. All current Australian temnocephalan species and their authorities are listed. A key to discriminate the Australia genera is presented, based on a small suite of morphological characters, most related to the organs of attachment and locomotion, and visible on live specimens with a stereo dissecting microscope. The aim of this key is to provide shortcuts to taxonomic identification that will help to reduce the practice of lumping, at the family level, temnocephalans collected in ecological, biomonitoring and biodiversity studies.

Keywords

Temnocephalida, Temnocephaloidea,, key, genus identification, *Didymorchis*, *Diceratocephala*, *Decadidymus*, *Actinodactylella*, *Temnomonticellia*, *Temnohaswellia*, *Achenella*, *Temnosewellia*, *Notodactylus*, *Craspedella*, *Gelasinella*, *Heptacraspedella*, *Zygopella*, crayfish, Parastacidae, Australia, checklist.

Introduction

Temnocephalans (Platyhelminthes, Temnocephalida) are small, active ectosymbiotic rhabdocoel turbellarians known mainly from Australia and South America where they occur on freshwater hosts, particularly crustaceans. They have a colourful early taxonomic history that was reviewed by Williams (1981). Most temnocephalan genera lack locomotory cilia, and have a posterior attachment organ, frequently referred to as a 'sucker', which they use in tandem with the anterior tentacles to effect a looping 'leech-like' locomotion which confused the issue of their origins (Williams, 1981, Haswell; 1893a; Fyfe, 1942). The true taxonomic position of the Temnocephalida has now been resolved, and concomitantly, the temnocephalan status of a number of controversial Australian genera has been confirmed (Cannon and Joffe, 2001). There is arguably an overdue need to update the search image for Australian temnocephalans beyond that of a 'typical' or 'textbook' facies of a worm with five anterior tentacles and a circular posterior attachment organ or sucker (Figure 1).

A detailed understanding of the internal anatomy of temnocephalans is essential to confirm their taxonomy. The diagram in Figure 2 shows the anatomy of the Australian temnocephalan *Gelasinella powellorum* and been compiled from examination of wholemounts, histological sections and live worms. Species discrimination often requires very fine details of the reproductive organs to be elucidated using a compound light microscope with cleared preparations of the sclerotic parts of the male copulatory organ or cirrus and the vagina (see, for example Figure 3). Cannon and Sewell (1991) reviewed and provided a key for *Temnosewellia* from *Cherax* spp. crayfish in Australia and Sewell et al. (2006) reviewed and provided keys to all species of *Temnohaswellia* and *Temnosewellia* from *Euastacus* spp. crayfish in Australia.

Figure 1. *Temnosewellia* cf. *rouxi*, LM image of live worm showing the dorsal facies of a 'textbook' Australian temnocephalan with five anterior tentacles and a circular pedunculate posterior attachment organ or 'sucker'. The worm is ~ 3-4 mm long.

A key to species is beyond the scope of this publication. Instead, a simple key to discriminate the Australia genera is presented, based on a small suite of morphological characters, most related to the organs of attachment and locomotion, and visible on live specimens with a stereo dissecting microscope. The aim of this key is to provide shortcuts to taxonomic identification that will help to reduce the practice of lumping, at the family level, temnocephalans collected in ecological, biomonitoring and biodiversity studies.

Schockaert et al. (2008) stated that turbellarians are seldom, if ever, taken into account in biodiversity studies of freshwater habitats even though they are mostly present in high numbers of species and individuals. It is hoped that the key to the genera of Australian Temnocephalida presented here will help rectify this situation by allowing workers to more readily discriminate temnocephala taxa than has been possible in the past.

Many of the images presented here were compiled from light microscope (LM) still and video footage and scanning electron microscope (SEM) images collected while I was working at the Queensland Museum (QM) as: (1) a part-time PhD student of The University of Queensland (UQ) from 1992 to 1998; and (2) a full-time researcher employed by James Cook University in 2002. Some of the video derived images are less than optimal quality, and lack a scale bar. They are, nonetheless, of sufficient resolution to elucidate the key characters.

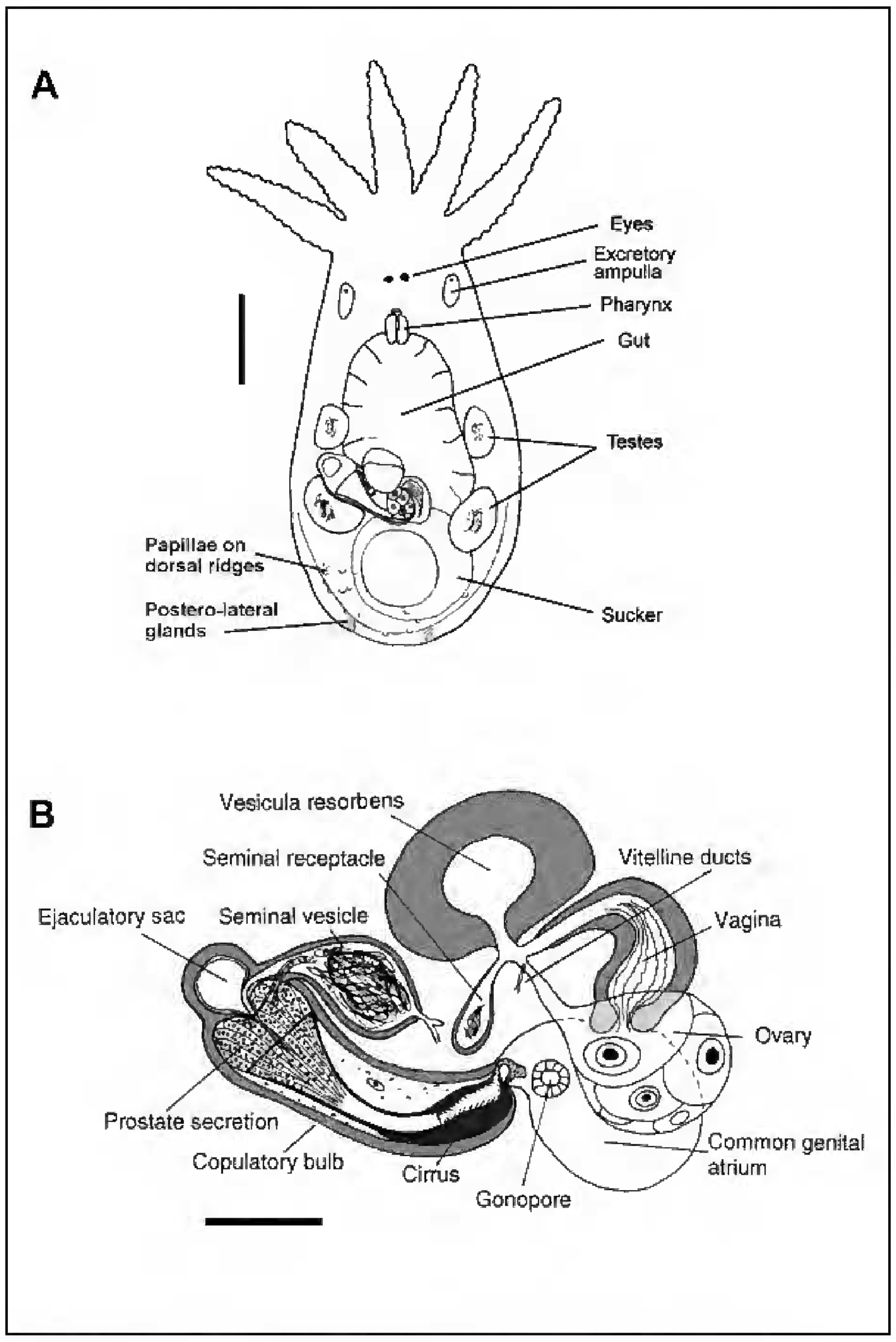

Figure 2. Diagram of *Gelasinella powellorum* showing: A, internal structure. Scale = 100 µm ; and B, reproductive structures. Scale = 50 µm.

Classification

Early workers were unable to determine the true rhabdocoel affinities of the taxon. Temnocephalans from Chile were originally classified as leeches by Monquin-Tandon (1986) and temnocephalans from the Philippines were classified as monogeneans by Semper (1872). In Australia, temnocephalans were initially misidentified as aberrant monogenean trematodes by Haswell (1888), before he, (Haswell, 1893a) recognised their rhabdocoel affinities. The taxonomic status of the Temnocephalida remained, however, controversial for more 150 years. Ehlers (1985) recognised that temnocephalans were undoubtedly related to rhabodcoel turbellarians, but could not provide a clear apomorphy to separate them.

It now well accepted that temnocephalans belong to the Rhabdocoela and are characterised by the presence of an epidermis made of multiple syncytial plates *i.e.* a syncytial mosaic (Figure 4; Joffe, 1982; Cannon and Joffe, 2001; Joffe et al.1995a,b; Joffe and Cannon 1998; Damborenea and Cannon, 2001; Amato et al. 2007, 2010). This uniquely temnocephalan character allowed confirmation of the status of the taxonomically controversial, and apparently early derived Australasian worms, *Didmorchis* and *Diceratocephala*, which both move by ciliary gliding, in place of the typical looping locomotion used by most temnocephalan species (Williams, 1981; Joffe et al. 1995a,b; Cannon and Joffe, 2001; Damborenea and Cannon, 2001).

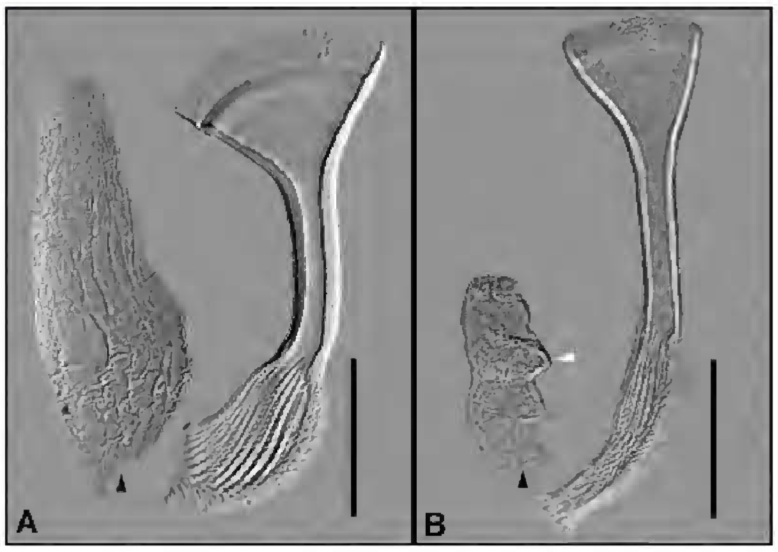

Figure 3. Faure's medium preparation of cirri and vagina of: A, *Craspedella simulator*; and B, *C. spenceri* to show the relationships between the shape of the cirrus introvert and the shape of the vaginal cavity by Nomarski interference microscopy. Scale = 50 µm.

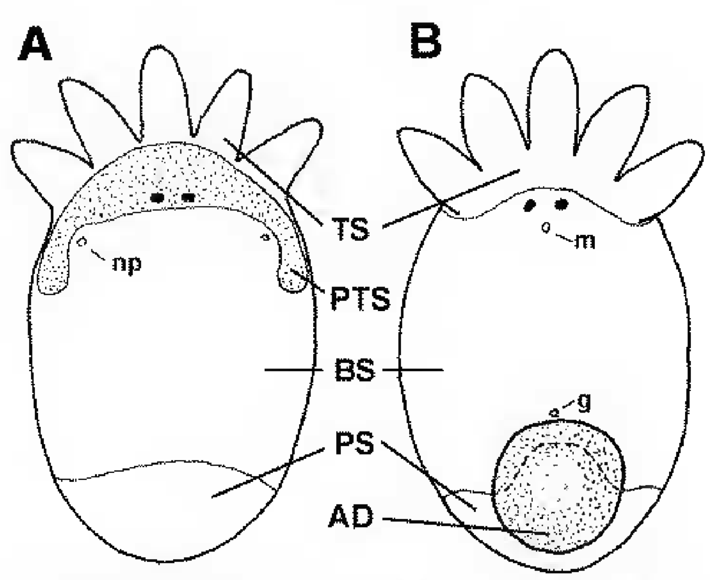

Figure 4. The syncytial mosaic of *Temnosewellia cypellum* A, dorsal view; B, ventral view. AD, Adhesive disc syncytium; BS, body syncytium; PS, peduncular syncytium; PTS, post-tentacular syncytium; TS, tentacular syncytium; g, gonopore; m, mouth; np, nephridiopore. From Sewell et al. (2006).

Composition of the Australian Temnocephalida fauna

According to the online database available at http://turbellaria.umaine.edu/ the Temnocephalida contains around 23 genera and 122 species worldwide (Tyler et al. 2006-2012). Australasia contains only temnocephalans from the 'southern group' or Temnocephaloidea, and these have radiated strongly with their parastacid hosts, particularly in Australia which is recognised as the global centre of temnocephalan diversity (Cannon, 1991; Cannon and Joffe, 2001; Sewell et al., 2006). Temnocephalida from the 'northern group' or Scutarielloidea are not found in Australia. The global biogeography of temnocephalans was analysed by Cannon and Joffe (2001). The type hosts and localities of Australia temnocephalan species are available on-line from (Tyler et al. 2006-2012) with many of the type localities linked to satellite images.

Australia has a total of 91 named temnocephalan species comprised of 13 genera, *viz. Didymorchis*, *Diceratocephala*, *Decadidymus*, *Actinodactylella*, *Temnomonticellia*, *Temnohaswellia*, *Achenella*, *Temnosewellia*, *Notodactylus*, *Craspedella*, *Gelasinella*, *Heptacraspedella* and *Zygopella* (Tables 1 and 2). Other regions of the world where temnocephalans are found, have considerably fewer genera (Schockaert et al., 2008). In South America, there are only two genera (*Temnocephala* and *Didymorchis*), although there is a greater diversity of host taxa e.g. crustaceans, molluscs, insects and chelonians (Damborenea and Cannon, 2001; Schockaert et al., 2008; Damborenea and Brusca, 2009). All the temnocephalans in Australia assigned previously to the genus *Temnocephala*, were transferred to *Temnosewellia* by Damborenea and Cannon (2001). *Temnosewellia* currently has the largest number of Australian species *i.e.* 52 (Table1). Six of the 13 Australian genera are currently monotypic, but it can be predicted confidently that the number of species in all genera will increase with closer examination of Australian hosts (Table 1)..

Table 1. Summary of the taxonomy of Australian Temnocephalida and the number of species from Table 1.

Family	Subfamily	Genera	Number of species
Didymorchiidae	-	*Didymorchis*	2
Actinodactylellidae	-	*Actinodactylella*	1
Diceratocephalidae	-	*Diceratocephala*	1
Diceratocephalidae	-	*Decadidymus*	1
Temnocephalidae	-	*Achenella*	2
Temnocephalidae	-	*Temnomonticellia*	5
Temnocephalidae	-	*Temnosewellia*	52
Temnocephalidae	-	*Temnohaswellia*	12
Temnocephalidae	-	*Notodatylus*	1
Temnocephalidae	Craspedellinae	*Craspedella*	9
Temnocephalidae	Craspedellinae	*Gelasinella*	1
Temnocephalidae	Craspedellinae	*Heptacraspedella*	1
Temnocephalidae	Craspedellinae	*Zygopella*	3

Collection and preservation

Temnocephalan worms have soft bodies and are easily damaged if handled roughly or temperature-shocked. Worms are best left attached to their crustacean hosts during transit to the processing locality. Hosts and worms should be maintained at a suitable temperature in good quality water, preferably from the habitat in which they were collected. Hosts should be transported only with sufficient water to cover them, and the number of hosts adjusted per container according to the size, aggression and moult status (= softness). Hosts should be segregated appropriately to ensure that temnocephalans, which are highly mobile, cannot transfer between them.

Temnocephalans are generally more sensitive to temperature changes than their hosts, and will die or rapidly break down if temperature shocked. The internal structures of temnocephalans, deteriorate very rapidly after death. To ensure the health of hosts and worms, the temperature of water in containers should be adjusted until close to the temperature of the habitat in the wild. This can be done, for example, inside an esky chilled with ice. In the case of very cold-tolerant large spiny mountain crayfish hosts and their worms, it can be valuable to cool them down slowly during transit i.e. until the hosts are torpid. This reduces host and worm damage and benefits safe removal of the worms during processing. Aggressive aeration of the water is likely to be harmful to temnocephalans, particularly those of the external carapace. If small containers are used to hold crayfish hosts, then a piece of plastic mesh should be placed into each container with the crayfish to support the crayfish in the air in case the oxygen content of water becomes depleted. Temnocephalans naturally move to regions on the host where they can remain moist and thus they can tolerate short of exposure of the host to air.

Hosts can be searched for temnocephalans using a dissecting microscope with cold incident light. Indeed, a great amount can be learned from observation of live worms, either on, or off the host. Video footage can be a valuable adjunct to detailed notes, drawings and still images. Worms can be removed alive from the surface of the host exoskeleton external carapace using a sharp wooden point, fine forceps or moist brush, generally without harm to the host. Quick transfer (seconds) to fresh water or fixative is desirable. For most worms, the use of a pipette will result in frustration as they are very difficult to dislodge once attached inside! For worms that live in the branchial chamber, it may be necessary to remove the carapace and gills to a shallow vessel containing water from the habitat. The gills break down quickly and worms should be removed to clean water as soon as possible. For isolated live worms in a shallow glass dish, a dissecting microscope with both incident and transmitted light allows effective observation and imaging.

For examination with a compound light microscopy, smaller worms can be transferred alive to a glass microscope slide and a cover slip added. Movement can be slowed effectively by careful regulation of the amount of water under the coverslip. The use of Nomarski interference optics is particularly useful to examine taxonomic details of the reproductive organs. Larger worms can be dissected and the component parts removed to a slide examined in the same way. Resolution of internal structures may not be possible otherwise, as can also be the case for species with dense body pigmentation.

Only adequate fixation for light microscopy can generally be achieved by the routine use of standard fixatives such as Bouin's fixative or 10% phosphate buffered formalin, either cold or at room temperature. These fixatives can cause live worms to contract and thus mask detail of epidermal structures. The use of hot fixatives is preferable to extend the worms and to reveal the syncytial mosaic (Sewell and

Cannon, 1995). There is, however, no one fixation technique suitable to reveal all the taxonomic features of temnocephalans, although the use of 100% ethanol comes closest (see below).

Some effective fixation protocols for routine light microscopy of temnocephalans are summarised below. Details on fixation protocols suitable for electron microscopy are not provided here but information on these can be found in Sewell and Cannon (1995), Joffe et al. (1998a,b) and Damborenea and Cannon (2001).

Cold 100% ethanol is a valuable 'all round' fixative for temnocephalans for the following reasons: worms fixed in this way are usually extended in a life-like manner and thus ideal for preparation of wholemounts; worms can be cleared and mounted unstained without the need for further dehydration; and worm tissue remains useful for DNA analysis; and worms can be rehydrated in water and mounted in Faure's medium to allow examination of the sclerotised components e.g. cirrus and vagina.

For light microscopy to show the epidermal mosaic that is characteristic for temnocephalans, live worms can be fixed by flooding with a solution of 2% silver nitrate heated to about 60°C, washed in distilled water then exposed to bright sunlight for 15 to 30 minutes, dehydrated in ethanol and mounted in Euparol.

Techniques to examine the sclerotic components of the cirrus and vagina

To show fine details of the cirrus and vagina (e.g. for species discrimination), Faure's mounting medium (distilled water 50 ml; chloral hydrate 50g; glycerol 20ml and gum arabic 30g) is most valuable to clear the tissue surrounding the scelerotic components (Figure 2). Faure's medium is particularly effective on live worms or worms fixed in 100% ethanol, but less so on worms fixed with routine histological fixatives such as Bouins or 10% formalin. For large worms or those with dense body pigmentation, it may be necessary to carefully dissect out the reproductive organs prior to clearing. Sewell et al. (2006) provided details on how to prepare the cirrus and vagina using Faure's medium, and these techniques have been applied and expertly refined for Neotropical temnocephalans (see, for example, Damborenea and Brusca, 2009; Amato et al., 2010). These organs occur in the posterior end of the worms and allow for routine retention of this part for morphological identification (i.e. after mounting in Faure's medium) while allowing the anterior end to be available for DNA sequence studies.

Taxonomic features

Australian temnocephalans have distinctive dorsal facies readily visible on live specimens with a stereo dissecting microscope (Figure 5). The facies derive largely from the organs of attachment and locomotion, particularly the anterior tentacles, and the posterior attachment organ. The Key to genera of Australian Temnocephalida presented below, is based largely on characters related to the temnocephalan organs of attachment and locomotion. Sewell (1998) studied these on a wide variety of Australian temnocephalans and proposed an evolutionary series of the major genera of Temnocephaloidea which remains useful to illustrate the character variation (Figure 6). The evolution of the Temnocephalida was discussed in detail by Cannon and Joffe (2001) who included zoogeographical data with data from morphological analyses of a wide range of temnocephalan characters, including those associated with the attachment organs and the syncytial mosaic.

Morphological characters relevant to the Key to Genera of Australian Temnocephalida are discussed briefly below and are summarised in Table 2. Example images of these characters, where available, are presented within the key.

Locomotory cilia

Many Australian temnocephalans have tufts of elongate cilia on epidermal body regions, but these cilia are not used in locomotion. *Didymorchis* and *Diceratocephala* alone move using locomotory cilia that is present over all the ventral body surface i.e. they do not loop.

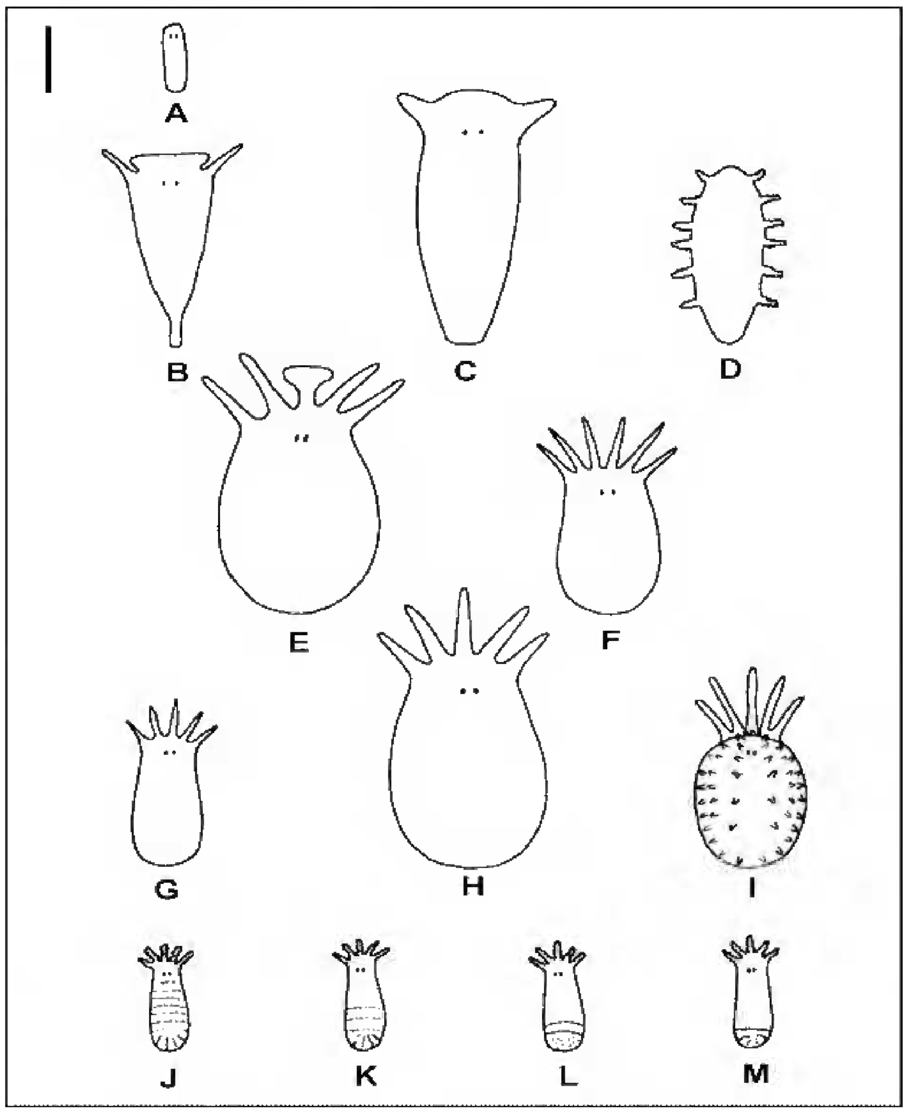

Figure 5. Dorsal facies of the 13 Australian temnocephalan genera: A, *Didymorchis*; B, *Diceratocephala*; C. *Decadidymus*; D. *Actinodactylella*; E, *Temnomonticellia*; F, *Temnohaswellia*; G, *Achenella*; H, *Temnosewellia*; I, *Notodactylus*; J, *Heptacraspedella*; K, *Craspedella*; L, *Gelasinella*; M, *Zygopella*. Scale bar = ~1 mm

Tentacles

Cannon and Joffe (2001) regarded as 'true' tentacles only those projection that with axial musculature. *Diceratocephala*, *Decadidymus* and *Actinodactylella* have structures that are 'tentacle-like' but which lack axial musculature (Cannon and Joffe, 2001). *Didymorchis* lacks either 'true tentacles' or 'tentacle-like' structures. No distinction is made in the present key between 'true- tentacles' and 'tentacle-like' structures i.e. both are heuristically regarded as tentacles. *Temnomonticellia* has five tentacles but the central (= medial) tentacle is shortened and 'bulb-like'.

Dorsal scales

The only temnocephalan known to have scales is *Notodactylus*. The dense 'tile-like' dorsal scales of

Notodactylus are of rhabdite secretion origin according to Jennings et al. (1992).

Dorsal papillate ridges

The Craspedellinae are alone in having papillae raised on posterior dorsal ridges with prominent raised papillae. There are transverse rows and posterior ridges that are arranged radially behind the most posterior transverse ridge. *Notodactylus* has sparse rows of elongate papillae on the dorsal surface but these are not on ridges (Sewell, 1998).

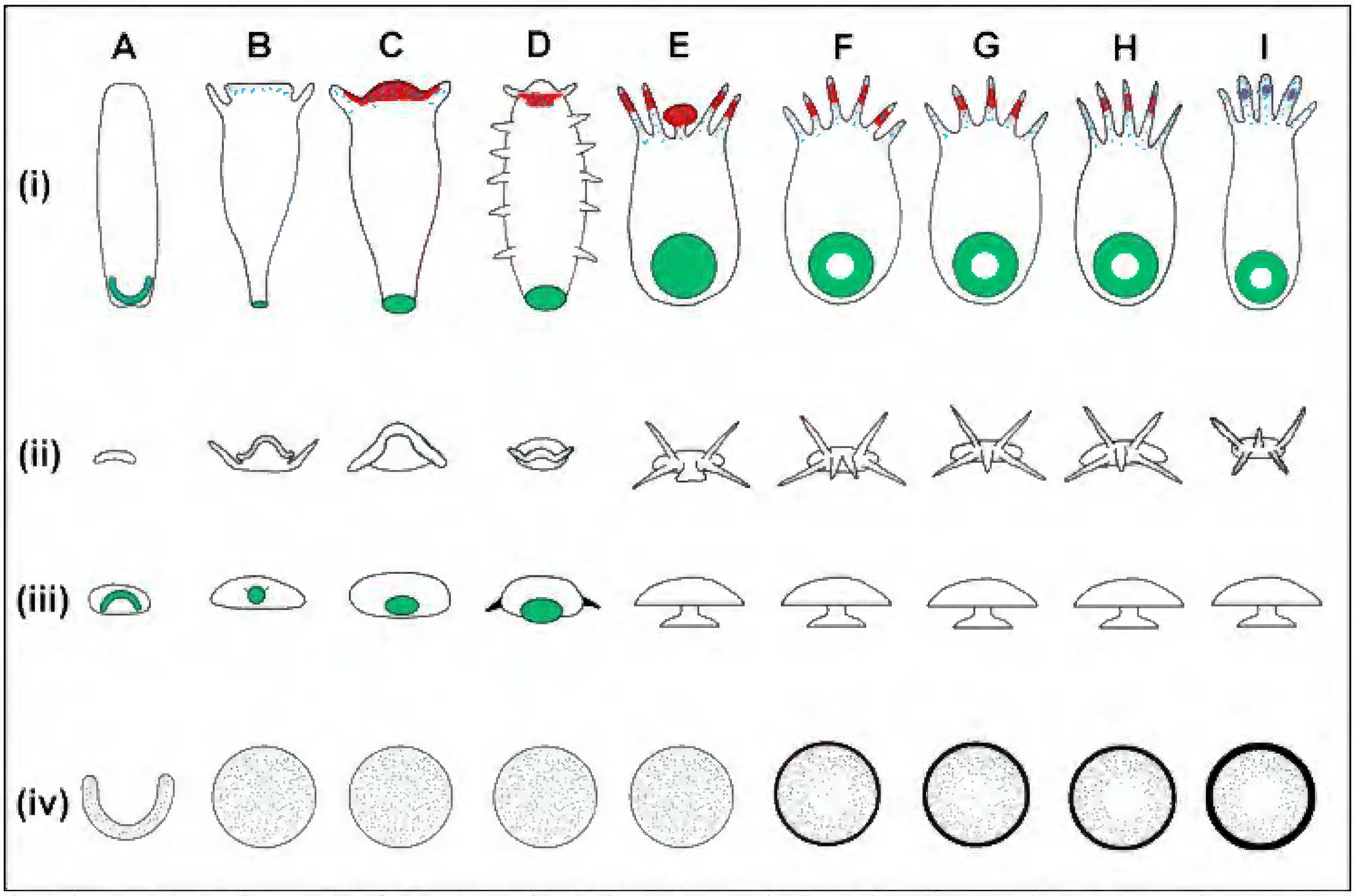

Figure 6. Proposed evolutionary series of major genera of Australian Temnocephalida illustrating: (i) Ventral view showing anterior (red) and posterior (green) adhesive regions and rhabdite distributions (rods) used to attach to the substrate during locomotion; (ii) *en face* view to show how anterior is held in life; (iii) *en posterior* view of how adhesive organ is held in life; (iv) posterior adhesive field showing the distribution of gland openings (black dots) and the presence of a marginal valve (dark black circle). **A**, *Didymorchis* **B**, *Diceratocephala* **C**, *Decadidymus* **D**, *Actinodactylella* **E**, *Temnomonticellia* **F**, *Temnohaswellia* **G**, *Temnosewellia* **H**, *Notodactylus* **I**, Craspedellinae (*Heptacraspedella*, *Craspedella*, *Gelasinella* and *Zygopella*) (From Sewell, 1998).

Conical ciliated papillae in rows on tentacles

The Craspedellinae have prominent conical ciliated papillae arranged in rows on their tentacles. *Actinodactylella* also have prominent ciliated papillate on their tentacles. It may be that the form of these papillae relates to the branchial chamber habitat of both of these specialised taxa.

Testes

Most Australian Temnocephalidae have two pairs of testes i.e. an anterior and a posterior pair (Figure 2). *Decadidymus* has 10 pairs of testes and *Didymorchis*, *Diceratocephala* and *Achenella* each have one pair. The testes can often be seen in live worms using a dissecting light microscope with transmitted lighting, but in the case of large worms or those with dense body pigmentation, wholemounts of fixed and histologically cleared specimens may be required.

Table 2. Matrix of morphological characters used below in the Key to genera of Australian Temnocephalida.

Genus	Locomotory cilia (Y/N)	Number of tentacles	Medial tentacle bulb-shaped (-/Y/N)	Dorsal scales(Y/N)	Number of dorsal papillate ridges	Ciliated papillae in rows on tentacles (Y/N)	Number of pairs of testes
Didymorchis	Y	0	-	N	0	N	1
Diceratocephala	Y	2	-	N	0	N	1
Decadidymus	N	2	-	N	0	N	10
Actinodactylella	N	12	-	N	0	Y	2
Temnohaswellia	N	6	N	N	0	N	2
Temnomonticellia	N	5	Y	N	0	N	2
Temnosewellia	N	5	N	N	0	N	2
Achenella	N	5	N	N	0	N	1
Notodactylus	N	5	N	Y	0	N	2
Zygopella	N	5	N	N	1	Y	2
Gellasinella	N	5	N	N	2	Y	2
Craspedella	N	5	N	N	3	Y	2
Heptacraspedella	N	5	N	N	7	Y	2

Checklist of Australian Temnocephalida

Australian temnocephalan species and authorities derived from the database available at http://turbellaria.umaine.edu/ (Tyler *et al*., 2006-2012). Authorities are listed in the references section. Type hosts and type localities are not listed here but are available in Tyler *et al*. (2006-2012).

TEMNOCEPHALIDA Blanchard, 1849
- **TEMNOCEPHALOIDEA Baer 1953**
  - **ACTINODACTYLELLIDAE Benham 1901**
    - ***Actinodactylella* Haswell, 1893**
      - *Actinodactylella blanchardi* Haswell, 1893
  - **DICERATOCEPHALIDAE Joffe, Cannon, and Schockaert, 1998**
    - ***Diceratocephala* Baer, 1953**
      - *Diceratocephala boschmai* Baer, 1953
    - ***Decadidymus* Cannon, 1991**
      - *Decadidymus gulosus* Cannon, 1991
  - **DIDYMORCHIIDAE Bresslau and Reisinger, 1933**
    - ***Didymorchis* Haswell, 1900**
      - *Didymorchis astacopsidis* Haswell, 1915
      - *Didymorchis cherapsis* Haswell, 1915
  - **TEMNOCEPHALIDAE Monticelli, 1899**
    - ***Achenella* Cannon, 1993**
      - *Achenella cougal* Cannon, 1993
      - *Achenella sathonota* Cannon, 1993
    - ***Notodactylus* Baer 1953**
      - *Notodactylus handschini* (Baer, 1945)
    - ***Temnohaswellia* Pereira and Cuoccolo, 1941**
      - *Temnohaswellia alpina* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia breviumbella* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia capricornia* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia comes* (Haswell, 1893)
      - *Temnohaswellia cornu* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia crotalum* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia munifica* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia pearsoni* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia simulator* (Haswell, 1924)
      - *Temnohaswellia subulata* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia umbella* Sewell, Cannon and Blair, 2006
      - *Temnohaswellia verruca* Sewell, Cannon and Blair, 2006
    - ***Temnomonticellia* Pereira and Cuoccolo, 1941**
      - *Temnomonticellia aurantica* (Haswell, 1900)
      - *Temnomonticellia fulva* (Hickman, 1967)
      - *Temnomonticellia pygmaea* (Hickman, 1967)
      - *Temnomonticellia quadricornis* (Haswell, 1893)
      - *Temnomonticellia tasmanica* (Haswell, 1900)
    - ***Temnosewellia* Damborenea and Cannon 2001**
      - *Temnosewellia acira* (Cannon and Sewell, 2001)
      - *Temnosewellia acicularis* Sewell, Cannon and Blair, 2006
      - *Temnosewellia alba* Sewell, Cannon and Blair, 2006
      - *Temnosewellia albata* Sewell, Cannon and Blair, 2006

Temnosewellia aphyodes Sewell, Cannon and Blair, 2006
Temnosewellia apiculus Sewell, Cannon and Blair, 2006
Temnosewellia arga Sewell, Cannon and Blair, 2006
Temnosewellia argeta Sewell, Cannon and Blair, 2006
Temnosewellia argilla Sewell, Cannon and Blair, 2006
Temnosewellia aspinosa Sewell, Cannon and Blair, 2006
Temnosewellia aspra Sewell, Cannon and Blair, 2006
Temnosewellia athertonensis (Cannon, 1993)
Temnosewellia bacrio Sewell, Cannon and Blair, 2006
Temnosewellia bacrioniculus Sewell, Cannon and Blair, 2006
Temnosewellia batiola Sewell, Cannon and Blair, 2006
Temnosewellia belone Sewell, Cannon and Blair, 2006
Temnosewellia butlerae (Cannon, 1993)
Temnosewellia caeca (Haswell, 1900)
Temnosewellia caliculus Sewell, Cannon and Blair, 2006
Temnosewellia cestus Sewell, Cannon and Blair, 2006
Temnosewellia chaerapsis (Hett, 1925)
Temnosewellia christineae (Cannon and Sewell, 2001)
Temnosewellia cita (Hickman, 1967)
Temnosewellia comythus Sewell, Cannon and Blair, 2006
Temnosewellia coughrani Sewell, Cannon and Blair, 2006
Temnosewellia cypellum Sewell, Cannon and Blair, 2006
Temnosewellia dendyi (Haswell, 1893)
Temnosewellia engaei (Haswell, 1893)
Temnosewellia fasciata (Haswell, 1888)
Temnosewellia fax Sewell, Cannon and Blair, 2006
Temnosewellia flammula Sewell, Cannon and Blair, 2006
Temnosewellia geonoma (Williams, 1980)
Temnosewellia gingrina Sewell, Cannon and Blair, 2006
Temnosewellia gracilis Sewell, Cannon and Blair, 2006
Temnosewellia iheringi (Haswell, 1893)
Temnosewellia improcera (Cannon, 1993)
Temnosewellia keras Sewell, Cannon and Blair, 2006
Temnosewellia maculata Sewell, Cannon and Blair, 2006
Temnosewellia magna Sewell, Cannon and Blair, 2006
Temnosewellia maxima Sewell, Cannon and Blair, 2006
Temnosewellia minima Sewell, Cannon and Blair, 2006
Temnosewellia minor (Haswell, 1888)
Temnosewellia minuta (Cannon, 1993)
Temnosewellia neqae (Cannon, 1993)
Temnosewellia muscalingulata Sewell, Cannon and Blair, 2006
Temnosewellia phantasmella (Cannon and Sewell, 2001)
Temnosewellia possibilitas Sewell, Cannon and Blair, 2006
Temnosewellia punctata (Cannon, 1993)
Temnosewellia queenslandensis (Cannon, 1993)
Temnosewellia rouxii (Merton, 1914)
Temnosewellia semperi (Weber, 1890)
Temnosewellia unguiculus Sewell, Cannon and Blair, 2006

CRASPEDELLINAE Baer 1931

***Craspedella* Haswell, 1893**

Craspedella bribiensis Sewell and Cannon, 1998
Craspedella cooranensis Sewell and Cannon, 1998
Craspedella gracilis Cannon and Sewell, 1995
Craspedella joffei Sewell and Cannon, 1998
Craspedella pedum Cannon and Sewell, 1995
Craspedella shorti Cannon and Sewell, 1995
Craspedella simulator Cannon and Sewell, 1995
Craspedella spenceri Haswell, 1893
Craspedella yabba Cannon and Sewell, 1995

***Gelasinalla* Sewell &Cannon, 1998**

Gelasinella powellorum Sewell and Cannon, 1998

***Heptacraspedella* Cannon and Sewell, 1995**

Heptacraspedella peratus Cannon and Sewell, 1995

***Zygopella* Cannon and Sewell, 1995**

Zygopella deimata Cannon and Sewell, 1995
Zygopella pista Cannon and Sewell, 1995
Zygopella stenota Cannon and Sewell, 1995

Key to the genera of Australian Temnocephalida

Note: This key is heuristic and not meant to imply phylogenetic relationships.

1a. With tentacles 2
1b. Without tentacles .... *Didymorchis* (Figure 7)

Figure 7. *Didymorchis*
Dorsal view (LM image). Scale = ~500µm.

2a(1a). With two tentacles 3
2b(1a). With more than two tentacles 4

3a(2a). With functional locomotory cilia .... *Diceratocephala* (Figure 8)
3b(2a). Without functional locomotory cilia .... *Decadidymus* (Figure 9)

Figure 8. *Diceratocephala*
Dorsal view (LM image).

Figure 9A. *Decadidymus*
Dorsal view (LM image from video).

Figure 9B. *Decadidymus*
Ventral view (X-ray image).

4a(2b). With 12 tentacles...*Actinodactylella* (Figure 10)
4b(2b). With fewer than 12 tentacles..5

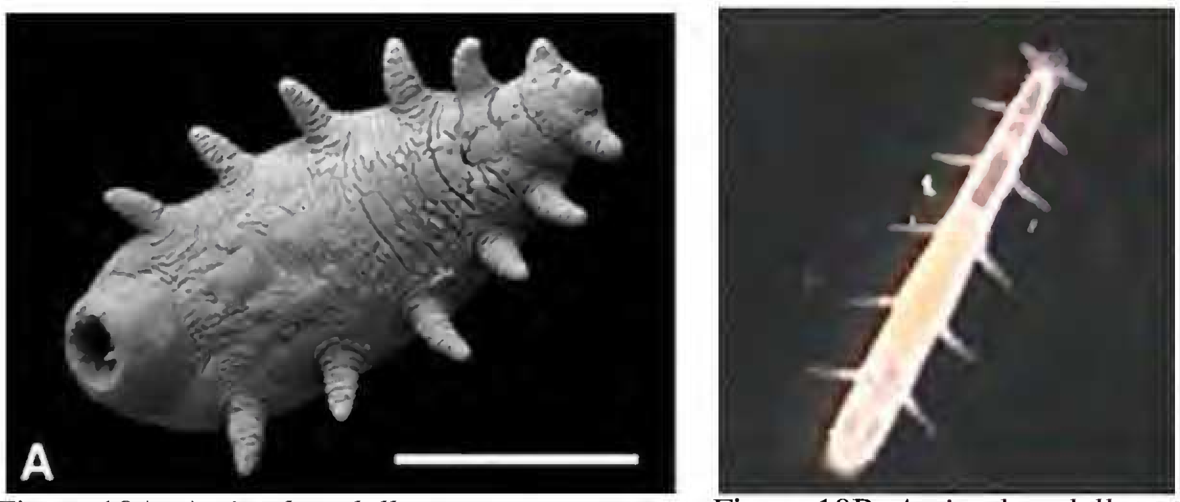

Figure 10A. *Actinodactylella*
Ventral view (SEM image). Scale = 200 µm.

Figure 10B. *Actinodactylella*
Dorsal view (LM image from video).

5a(4b). With 5 tentacles..6
5b(4b). With 6 tentacles ....*Temnohaswellia* (Figure 11)

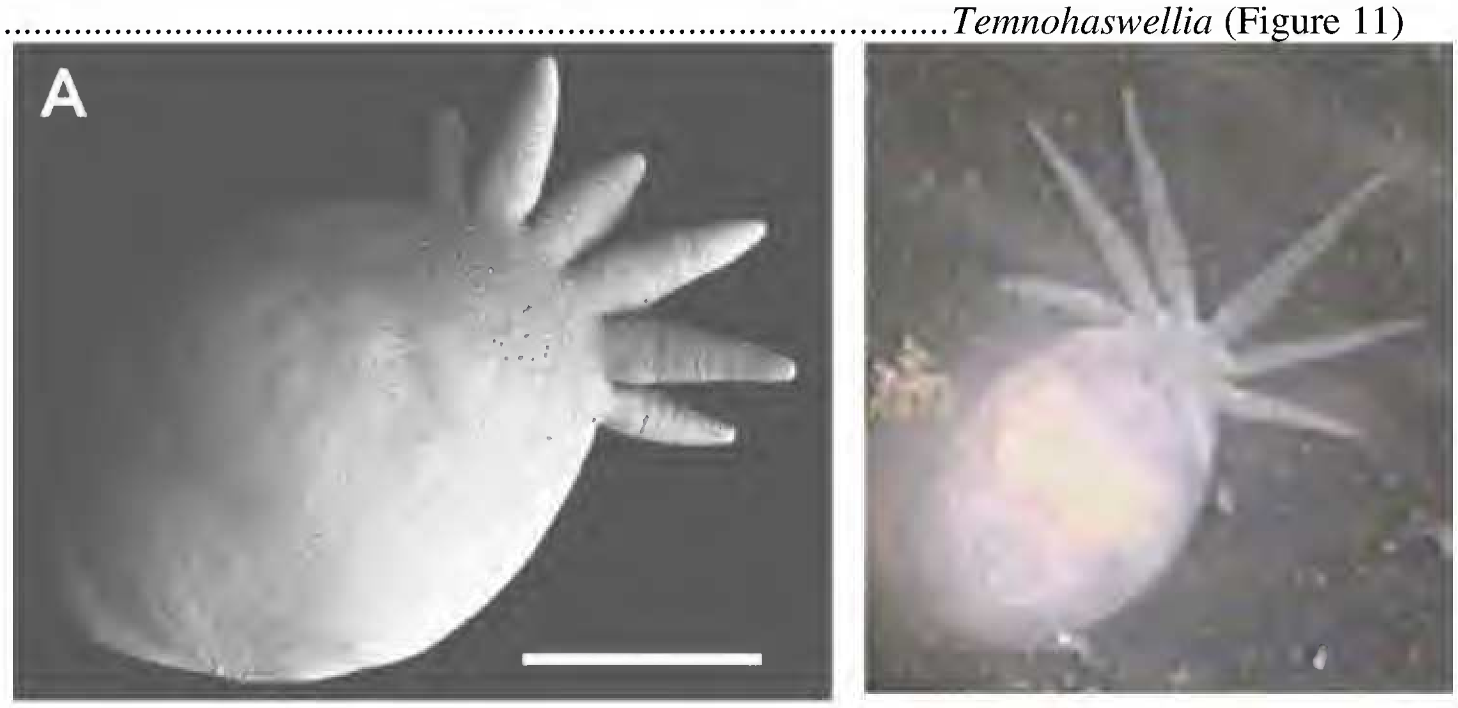

Figure 11A. *Temnohaswellia*
Dorsal view (SEM image). Scale = 500 µm.

Figure 11B. *Temnohaswellia*
Ventral view (LM image from video).

6a(5a). With medial tentacle transformed into a short bulb...*Temnomonticellia* (Figure 12)
6b(5a). With medial tentacle not transformed into a short bulb 7

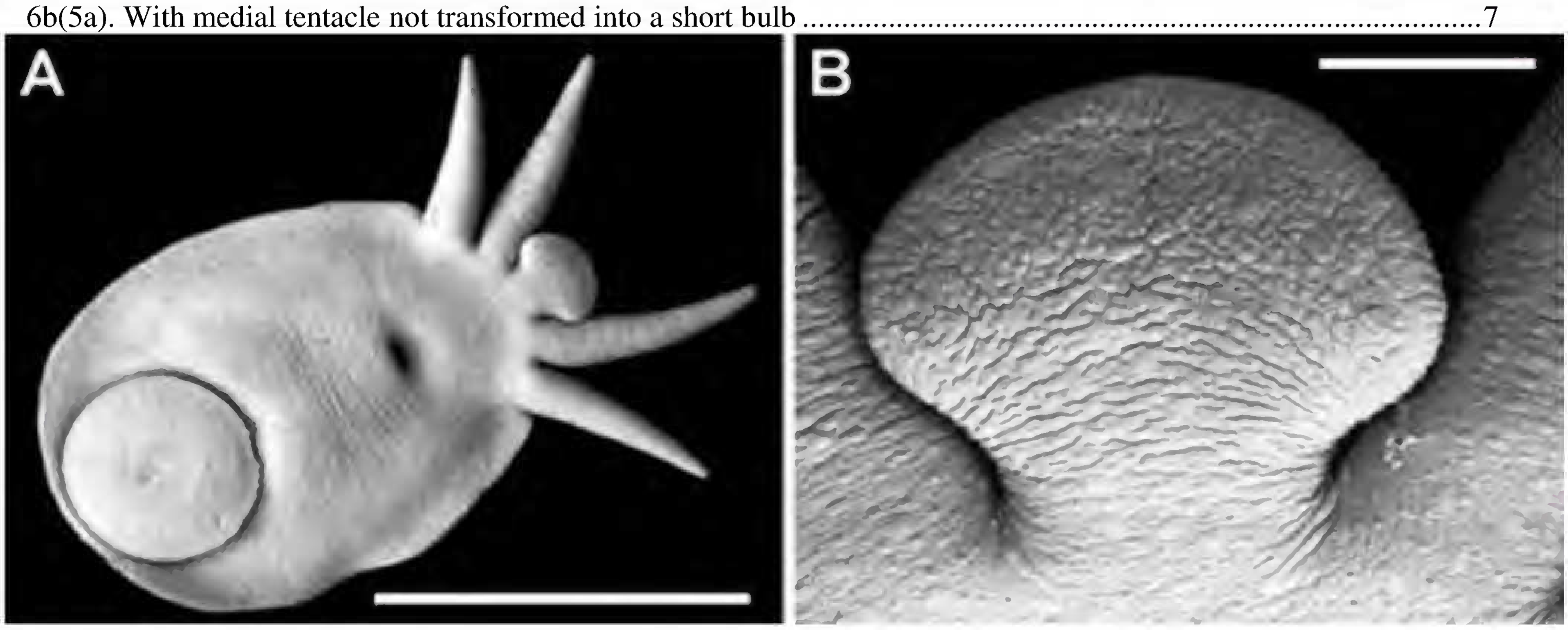

Figure 12. *Temnomonticellia*
A, ventral view. Scale = 2 mm.
B, central tentacle 'bulb' (SEM images). Scale = 200 µm.

7a(6b). With scales on dorsal body surface .... *Notodactylus* (Figure 13)
7b(6b). Without scales on dorsal body surface 8

Figure 13A. *Notodactylus*
Dorsal view of silver nitrate stained worm (LM image). Scale = 500 μm.

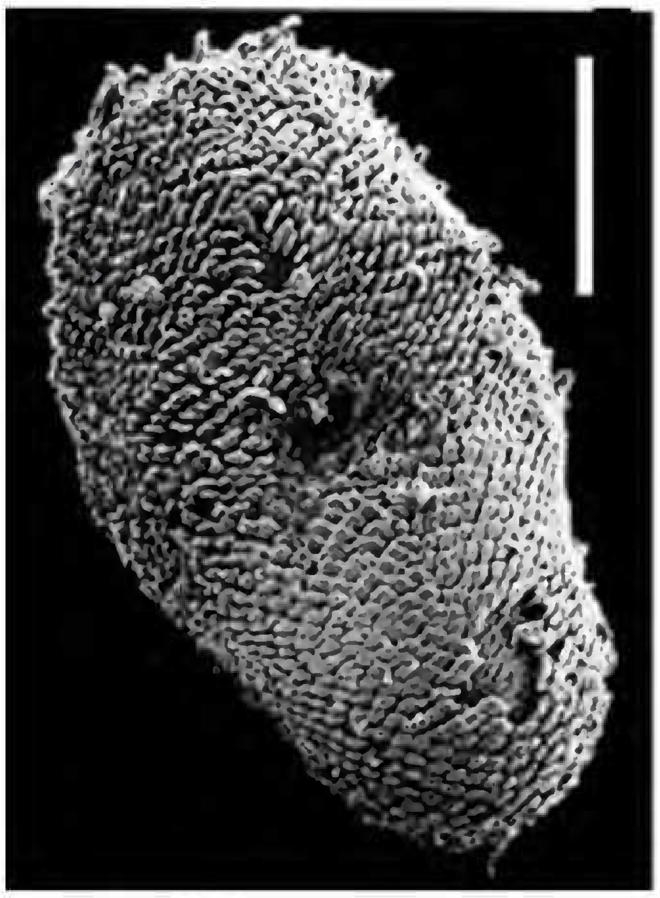

Figure 13B. *Notodactylus*
Dorsal view of worm (SEM image). Scale = 500 μm.

8a(7b). With prominent cilated papillae in rows on tentacles (see, for example, Figure 14, below) 9
8b(7b). Without prominent cilated papillae in rows on tentacles 12

Figure 14. Row of prominent ciliated papillae on tentacle From *Craspedella* (LM image).

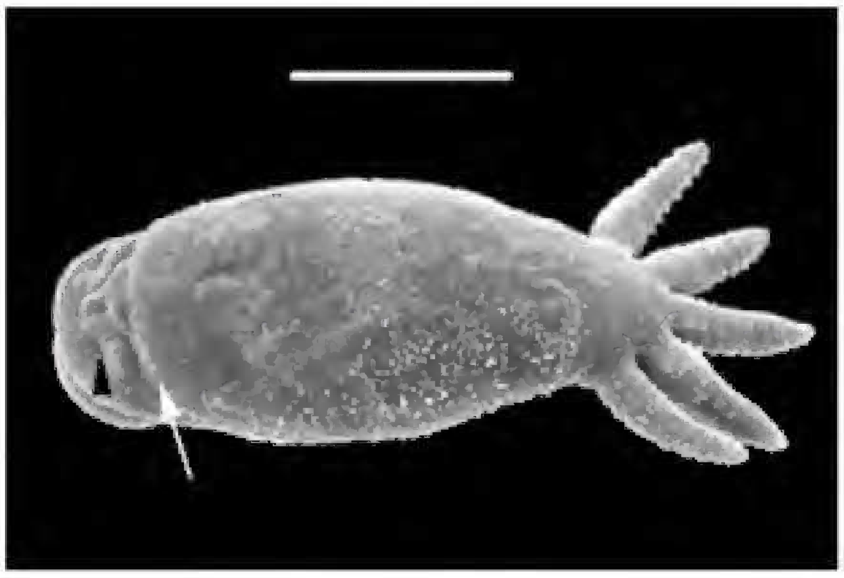

Figure 15. *Zygopella*.
Dorsal view showing the single transverse ridge (white arrow) (SEM image). Scale = 200 μm.

9a(8a). Dorsal body with one papillate transverse ridge ....*Zygopella* (Figure 15, above)
9b(8a). Dorsal body with more than one papillate transverse ridge 10

10a(5a). Dorsal body with two papillate transverse ridges .... *Gelasinella* (Figure 16, below)
10b(5a). Dorsal body with more than two papillate transverse ridges 11

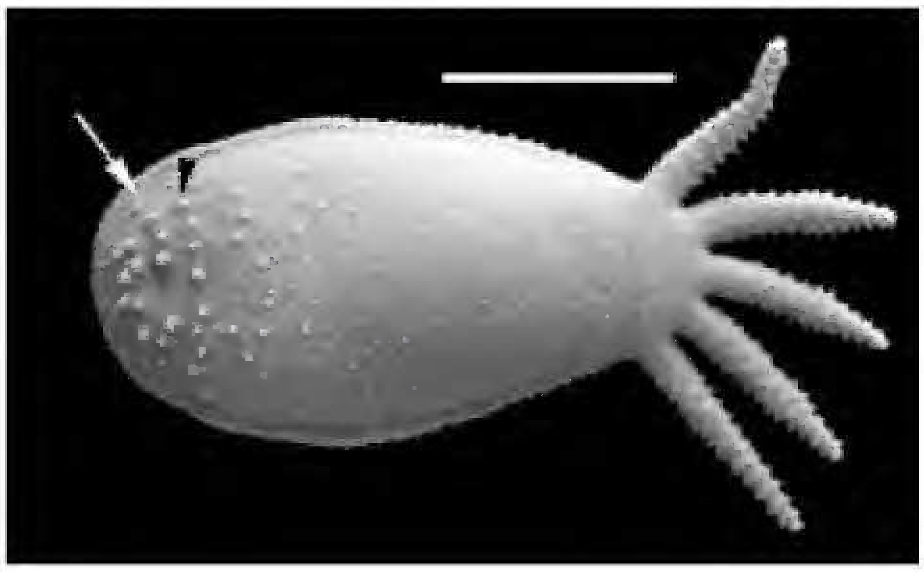

Figure 16. *Gelasinella*
Dorsal view showing the two transverse ridges (white arrow & black arrow head) (SEM image). Scale = 200 µm.

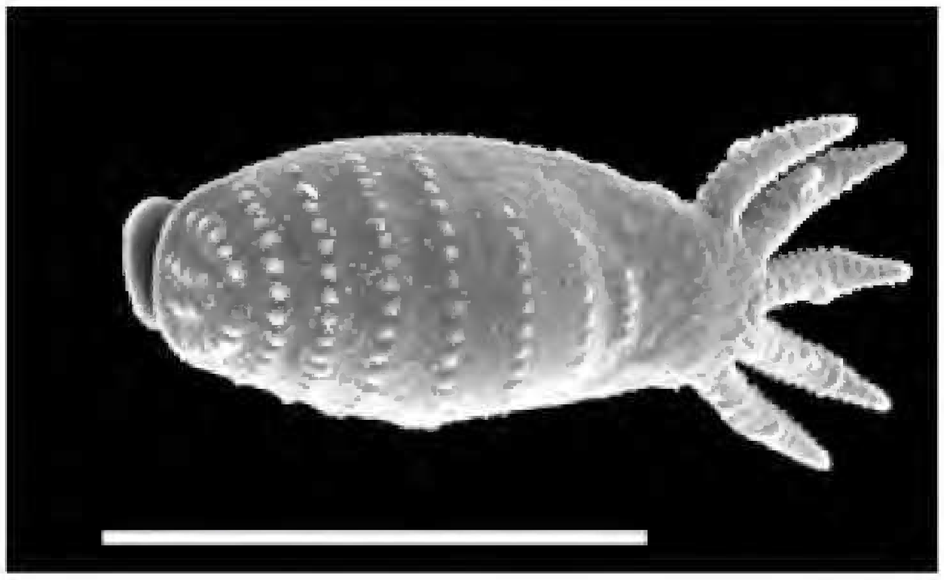

Figure 18. *Heptacraspedella*
Dorsal view(SEM image). Scale = 500 µm.

11a(10b). Dorsal body with 3 transverse ridges bearing raised papillae .... *Craspedella* (Figure 17A, B, below)
11b(10b). Dorsal body with 7 transverse ridges bearing raised papillae .... *Heptacraspedella* (Figure 18, above)

Figure 17A. *Craspedella*
Dorsal view (LM image from video).

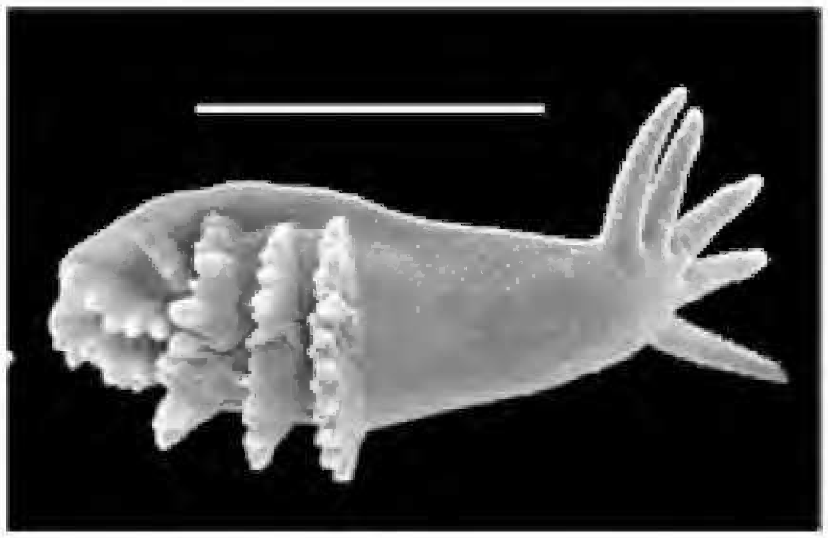

Figure 17B. *Craspedella*
Dorsal view (SEM image). Scale = 500 µm.

12a(8b). With a one pair of testes .... *Achenella* (Figure 19, below)
12b(8b). With a two pairs of testes .... *Temnosewellia* (Figure 20A, B, below)

Figure 19. *Achenella*
Dorsal view (LM image from video).
Testes not visible.

Figure 20A. *Temnosewellia*
Dorsal view (LM image).

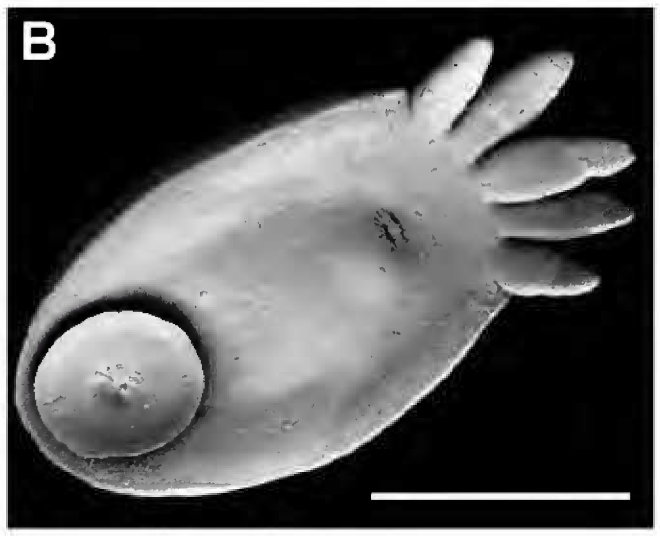

Figure 20B. *Temnosewellia*
Ventral view (SEM image). Scale = 2 mm.

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